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# TEACHING METHODS ENHANCING GRADE NINE STUDENTS' PERFORMANCE AND ATTITUDES TOWARDS BIOLOGY

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**Abstract:** The relationship between different teaching methods, lower secondary school students' performance in biology and their attitudes to learning biology were studied. The survey data consisted of 2 989 ninth grade students responses to from 97 comprehensive schools. Teacher-led instruction, individual work, interactive work, inquiry-based approach, visits outside the school, use of information and communications technology (ICT) and methods that enhanced students' autonomy were found when Likert-scaled items measuring the use of different teaching methods were analysed with explorative factor analysis (EFA). Multiple choice questions and production assignments were used to measure students' knowledge and cognitive skills. Attitude dimensions like the utility of biology, liking of biology as school subject and self-concept in learning of biology were also found with EFA. The EFA scores were analysed on the school level as the averages of 97 schools. Students' school-specific average performance in biology correlated strongly only with inquiry-based teaching method. Different attitude dimensions correlated more strongly with interactive work than with teacher-led instruction. Use of ICT correlated only slightly with the attitude dimensions of utility of biology and liking of biology as school subject. Visits outside the school did not correlate with any of the studied dimensions. The results indicate the importance of inquiry-based teaching approach in the lower secondary school biology. It is important for the students to make experimental investigations and observations, take part in biology demonstrations, ponder causes and effects and apply knowledge to everyday live. Student-centred, activating and participatory methods are essential to enhance students' attitudes to learning biology in the Finnish lower secondary school.

**Key words:** biology education, performance, attitudes, teaching methods, inquiry-based learning

## INTRODUCTION

The main goals of science education are to develop understandings of biological systems, the methods of scientific inquiry, prepare students to make responsible decisions concerning science-related social issues and inform students about possible science careers (Bybee, Carlson-Powell & Trowbridge, 2007). To reach these goals, different learning environments, teaching approaches and methods are important aspects to consider also in school biology education. For instance, Joyce and Weil (2011) define teaching as information processing models, personal models, social interaction models and behaviour modification models.

To develop science education, it is also important to know factors that influence students' performance and motivation to study. Many internal and external factors are known to influence students' achievements and interests in learning of science. In

many studies, attitudes have been found to play an important role in learning. For instance enjoyment of science, the beliefs on the utility of science and self-esteem at science are factors that influence students' attitudes (Osborne, Simon & Collins, 2003). Attitudes towards science are important personal factors that influence students' motivation to study different science subjects. For instance in Finland, students' interest in biology and their out-of-school experiences are found to relate with each other (Uitto, Juuti, Lavonen & Meisalo, 2006). Strong correlations between ninth graders' interest in biology, and their environmental values and attitudes have also been found, indicating the importance of affective factors in learning of biology and especially ecology and environmental issues (Uitto, Juuti, Lavonen, Byman, & Meisalo, 2011). As for the upper secondary school, students' interest in biology and their intentions to orientate towards biology-related future occupations were mostly related with the interest in biology topics and self-efficacy beliefs in the success in school biology (Uitto, in press). The learning outcomes and subject choices are influenced by the relative stable self-concept of the students, as well as their perception of their own skills to solve or run a specific, goal-oriented task (Bandura, 1997). Meta-analyses have shown that secondary students' self-efficacy contributes many ways to their academic performance (Multon, Brown, & Lent, 1991).

The role of the educational evaluation is to provide information on how the goals for the education have been reached. To clarify the relation of biology classroom activities and students' performance in biology and attitudes to learning biology, we used the large survey data provided by the Finnish National Board of Education (FNBE) (see Kärnä, Hakonen & Kuusela, 2012). For this study we asked the question: what is the relationship between teaching methods, grade nine students' performance in biology and attitudes to learning biology?

## **MATERIAL AND METHODS**

Large-scale surveys are able to provide overall information on factors influencing students' performance, motivation to study science subjects and orientate towards science-related occupations. In this study students' performance and attitudes to learning biology were investigated using the data provided by the FNBE (Follow-up assessment in natural sciences, Kärnä, Hakonen & Kuusela, 2012). The theoretical and methodological background for the attitudes can be related to the studies of Fennema and Sherman (1978) and Metsämuuronen (2012), for performance to Krathwohl (2002) and for teaching methods to Joyce and Weil (2011).

A stratified sampling method was used when collecting the nationally representative data in 2011. Together 2 989 grade nine students from 133 schools participated the study involving 52% of boys and 48% of girls. The items measuring teaching methods and attitudes to learning biology were analysed with explorative factor analysis (EFA) using Principal axis factoring and Oblimin with Kaiser Normalization rotation method. Only the items with loadings higher than 0.3 and factors with Cronbach's alfa higher than 0.6 were accepted to the final analyses. The factor score variables calculated by EFA were analysed on the school level, so that school-specific averages of each variable were calculated for 97 schools with at least 20 ninth graders. The results are presented as school level only. Relationship between different variables was studied by using Pearson's two-way correlation coefficients. To study how often each of the teaching methods were used, average for the items forming different variables were also calculated.

## Teaching methods

Teaching methods were studied with 29 items reflecting students' conceptions on how often various activities and learning environments were used in biology lessons. Students' responses were asked using a 5-point Likert-scale: 1 = never, 2 = seldom, 3 = sometimes, 4 = often, 5 = almost always. For instance teaching method emphasizing teacher-led instruction includes statements like: *The teacher teaches a new topic by writing notes on the blackboard* and *Students make notes in their notebook and use them in their studies*. The items measuring for instance inquiry-based approach concerned the following activities: pondering of causes and effects, making observations, stating different viewpoints to the studied phenomena, applying learned issues to everyday life, making experimental work and taking part to demonstrations. The items were reduced by using explorative factor analysis (EFA).

## Performance in biology

The assignments to measure performance in biology were chosen to reflect the objectives and contents of biology mentioned in the core curriculum for basic education (NFBE, 2004). Together there were 36 multiple choice questions and six production assignments, which measured factual and conceptual knowledge, procedural knowledge and cognitive skills. The assignments consisted of 1) reproduction, heredity, evolution, 2) human structure and vital functions, 3) the structure and function of ecosystems, and 4) the structure and classification of organisms (Kärnä et al., 2012).

## Attitudes to learning biology

According to Fennema & Sherman (1978) and Metsämuuronen (2012), affective factors concerning students' beliefs on their learning can be divided into three different attitude dimensions; a) liking the subject (e.g. *I like biology lessons*), utility of the subject (e.g. *Biological knowledge and skills are important in everyday-life situations*) and self-concept in the subject (e.g. *I think I' am good in biology*). These factor dimensions were also used in this study to find out students' attitudes to learning biology at school. Attitudes were measured with a 5-point Likert-scale: 1 = totally disagree, 2 = rather disagree, 3 = nor disagree or agree, 4 = rather agree, 5 = totally agree.

## RESULTS

### Teaching methods

To reduce the data, two different EFA was carried out, because it was not possible to find reliable factor solution for all teaching method items together. For the first analysis items that reflected inquiry-based approach and different learning environments provided the best EFA solution. For the second EFA items that emphasised other personal, social and information processing methods were used. In the first EFA three factors were found, in which the number of items varied from two to six and Cronbach's alfa varied from 0.6 to 0.8. The factors were named as *Inquiry-*

*based approach, ICT learning environment and Visits outside the school.* In the second EFA there were four factors, named as different teaching methods: *Group work/interactive work, Teacher-led instruction, Methods enhancing students' autonomy and Individual work.* The number of items in different factors varied from two to five. The last factor, Individual work, was left out from the further analysis, because its internal consistency was low (Cronbach's  $\alpha = 0.4$ ). In other factors the  $\alpha$  varied from 0.6 to 0.7. The averages of the first EFA factors items varied between 1.4 (visits outside the school) to 2.6 (inquiry-based approach) ( $SD = 0.65\text{--}0.83$ ), indicating that in students' opinion these teaching methods or learning environments were quite seldom used in biology education. As for the second EFA, the item averages varied from 2.6 (Group work/interactive work) to 4.2 (Teacher-led instruction) ( $SD = 0.67\text{--}0.90$ ).

## Performance and attitudes

In general, the success rates measured as the percentage of correct answers of the total score indicated that for the students it was most easy to remember factual and conceptual knowledge. The success rate was 59% in the assignments that measured remembering and understanding in knowledge concerning cell, plant, animal and human biology. Procedural knowledge concerning issues in evolution, human biology, ecology and microbiology was more demanding, because the success rate in these assignments was 39% (see Kärnä et al., 2012). Girls scores exceed significantly boys scores in both knowledge categories ( $t = 6.0\text{--}12.4$ ,  $p < 0.001$ ). The power of the difference varied from small to large (Cohen's  $d = 0.21\text{--}0.45$ ).

In analysing the attitudes with EFA, five different attitude items were loaded for each of the three attitude dimensions. Cronbach's  $\alpha$  varied from 0.8 to 0.9 for the factors, indicating high internal consistency. The item averages of different attitude dimensions varied from 3.1 to 3.3 ( $SD = 0.8\text{--}0.9$ ), revealing that the students had slightly positive attitudes to learning biology. Girls had higher factor scores in every attitude dimensions ( $t = 5.8\text{--}12.0$ ,  $df = 2\,979$ ,  $p < 0.001$ ,  $d = 0.2\text{--}0.4$ ).

## The relationship between teaching methods, performance and attitudes

The main results on the relationship between teaching methods, performance and different attitude dimensions are shown in the Table 1. Inquiry-based teaching approach was the only dimension that correlated strongly both with performance ( $r = 0.42$ ) and different attitude dimensions ( $r = 0.35\text{--}0.53$ ). Group work/interactive work as well as teaching methods that enhanced students' feeling of autonomy correlated significantly with all attitude dimensions ( $r = 0.37\text{--}0.51$ ). Teacher-led instruction correlated most strongly with the liking of biology as school subject ( $r = 0.36$ ). The use of ITC as learning environment correlated slightly with the attitude dimensions of the utility of biology and the liking of biology ( $r = 0.25\text{--}0.31$ ).

Table 1

*Pearson's correlation coefficients (r) between teaching methods, performance in biology and three attitude dimensions. The correlations are calculated using the means of 97 schools*

Teaching method or learning environment	Performance in biology	Attitude dimensions		
		Self-concept in biology	Utility of biology	Liking biology as school subject
Inquiry-based approach	.42**	.35**	.51**	.53**
Visits outside the school	-.056	-.11	-.05	-.04
ICT learning environment	.16	.09	.31**	.25*
Group work/Interactive work	.26*	.38**	.44**	.43**
Teacher-led instruction	.12	.29**	.29**	.36**
Methods enhancing students' autonomy	.18	.37**	.42**	.51**

*Note.* \* $p < 0.01$ , \*\* $p < 0.001$

## DISCUSSION

In this study the relative importance of different teaching methods on ninth grade students' performance in biology and attitudes to biology were investigated. The results emphasize learner-centred, inquiry-based and collaborative approaches for the performance in biology and positive attitudes to biology as a school subject. However, inquiry-based approach have not used routinely in the biology classroom. To develop biology education, it is important to take into account that pondering of causes and effects, making observations, stating different viewpoints to the studied phenomena, applying learned issues to everyday life, making experimental work and taking part into biology demonstrations are important to enhance both learning outcomes and evoke students' interest and motivation to study biology in the lower secondary school. Interactive teaching and methods that enhance students' autonomy were connected to all attitude dimensions, which emphasize the importance of affective and social factors in science education (Deci & Ryan, 2004; Krapp & Prezel, 2011; Osborne et al., 2003).

It is also important to know, that as such, the most frequently used teacher-led instruction was not related to students' performance in biology. However, teacher-led instruction correlated somewhat with the attitude dimensions, mostly with the liking of biology as school subject. This may indicate that the students liked that the biology teacher explains and discusses with them for instance on complex biological phenomena. It is plausible, that if teacher-led instruction and guidance is combined for instance with inquiry-based approach, learning would be effective both cognitively and affectively.

ICT is considered to be an important learning environment in teacher education and in everyday school-life in Finland (Lavonen, Krzywacki, Koistinen, Welzel-Breuer & Erb, 2012; Niemi, Kynäslähti, & Vahtivuori-Hänninen, 2012). However, this study reveals that as such, ICT did not enhance students' performance in biology but it correlated slightly with two attitude dimensions; the utility of biology and the liking of biology as school subject. More research would be needed to find out the benefits of ICT in biology education. ICT can be used various ways in learning biology, for instance the documentation of field trips and species identification by using mobile devices has been suggested (Uitto et al. 2006). Using ICT may also diminish gender differences in attitudes to learning biology at school (Uitto et al. 2006).

According to students' responses, visits outside the school were infrequently carried out and the visits did not have influence on students' learning outcomes. The visits did not enhance students' attitudes to learning biology, which is surprisingly because for instance a national history museum, botanical garden or zoo are considered as motivating learning environments (Dohn, 2013; Patrick & Tunnicliffe, 2013). Besides learning biology, visits outside the school could be used many ways to connect the surrounding society to school education. Visits could help students to understand socio-scientific issues and orientate towards future studies and occupations. However, learning in out-of-school environments are generally not well prepared and evaluated by the teachers (Kisiel, 2003), which is a challenge for teacher education. Schools' resources to organize visits are often limited, thus the few visits should be carefully planned and related to biology curriculum.

In conclusion, to develop secondary school biology education, it is important to notice that inquiry-based approach was the only method that clearly related to students' learning outcomes in biology. According to our study this means that students were actively using their cognitive skills to solve problems and applying their knowledge and skills in different situations. This probably means that the students were allowed to work with problems and questions that fit their interests and skills. Student-centred and collaborative teaching methods should be used to enhance students' attitudes to learning biology. More studies should be carried out to find out what kind of methods are cognitively and affectively valuable in ICT and out-of-school learning environments.

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